From the desk of...

Crude vibration amplitude measurements: Peak to peak versus S_{max}

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Vast increases in the knowledge of machinery behavior, along with excellent growth in the capabilities of electronic monitoring and diagnostic systems, are providing powerful information for protection, observation and management of machinery. A good analogy is the evolution of medicine. One hundred years ago, physicians used a few fundamental measurements, like temperature, to assess the condition of their patients. Advances in medical knowledge and instruments now provide the doctor with temperature, blood pressure, blood chemistry and much more information. The result is better assessment of a patient's condition. In the machinery behavior field, some of the information that significantly improves the management and protection of rotating equipment is:

- 1X peak to peak amplitude and phase lag
- 2X peak to peak amplitude and phase lag
- Sometimes other orders (nX) amplitude and phase lag
- Steady-state shaft position
- Not "1X" vibration (i.e., non-synchronous) vibration amplitude
- Shaft to housing modal probe measurements and online calculation of transmitted forces
- Shaft modal probe measurements

Measurements, such as peak to peak, zero to peak (single amplitude), S_{max} [single peak measurement of XY (orthogonal) probes against a calculated "quasi zero" point], RMS (Root Mean Square), possibly useful for noise measurement (and average), largely fall into the same category as a patient's temperature. They are crude and necessary but are not sufficient to manage modern machinery. However, since S_{max} is in use regionally around the world, and is being pushed strongly for incorporation in the vibration specification of the International Standards Organization, here is a presentation and comparison of peak to peak and S_{max}.

The practical measurement of the peak to peak amplitude of shaft motion, as well as XY (orthogonal) shaft motion, were made popular by Bently Nevada Corporation about thirty years ago. Both are generally well-known measurements; there is no great novelty attributed to them. Peak to peak displacement amplitude has enjoyed success because it usually allows calculation of **Percentage of Bearing or Seal Clearance** taken by the vibration, which S_{max} cannot provide. This percentage is a very important fundamental correlation on nearly all rotating machinery.

S_{max} was apparently developed to make more accurate peak measurements than simple peak to peak in two particular situations, which it does well:

1. For highly elliptical or flat motion (when that motion is around 45° orientation to the observing probes).

2. When the vibration motion consists primarily of vibrations of the type of 1/2X plus 1X, or 1X plus 2X, at the very special and unusual relationship that the harmonic motion **adds** to one of the fundamental peaks and subtracts from the other.

S_{max} does both of these jobs well. However, it is necessary to remember that peak vibration is a very crude measurement to begin with. There is very little purpose to apply high accuracy to these basic measurements.

Both peak to peak and S_{max} types of amplitude detectors require both a low frequency and high frequency cutoff (to respond rapidly and to eliminate some types of noise, respectively). However, S_{max} requires an extra elaborate calculation (the computation of the XY, "quasi zero," against which the readings of the orthogonal probes are compared) and must have a low frequency weighting. Unlike the steady state shaft position measurement, the S_{max} "quasi zero," to my knowledge, is not useful as a machinery measurement.

It is important to remember that any form of peak measurement is crude to begin with; therefore, there is little purpose to apply high accuracy to these basic measurements. The increased complexity of S_{max} makes it more expensive and less reliable, negating the benefits of improved accuracy in the two special cases. Even with modern digital electronics, the old rule, that the only 100% reliable part is the one that is not needed in the system, is true.

As a result of all the above considerations, it is my belief that the peak to peak shaft displacement measurement is the best choice as a basic (crude) shaft vibration measurement. Further advances in modern electronics need to be used to supply the additional information (mentioned in the beginning of this article) that improves the management and protection of rotating machinery. ■